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A Metrics Suite for Measuring Reusability of Learning Objects

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***Abstract*— Learning Object (LO) is one of the main research topics in the E-Learning community in the recent years, and most researchers pay attention to the issue of Learning Object Reusability. The most obvious motivation is the economic interest of reusing learning material instead of repeatedly authoring it. Reusability requires the LO to be in a fine-grain form because raw media elements are often much easier to reuse than aggregate assemblies. In other words, as the LO size decreases (lower granularity), its potential for reuse increases. Therefore, when designing learning objects, reusability must be considered as a key consideration. This paper shows how we adapted and applied some of the metrics from the software engineering field for the purpose of measuring reusability of learning objects.**

Keywords- learning object, reusability, metrics

I. INTRODUCTION

Electronic Learning or E-Learning provides an environment where learners are able to access educational materials, anytime and at any place. Most of the educational materials located in the web environment or learning portals are in the form of digital objects. These digital objects are also known as Learning Objects (LO) as they are used specifically for learning purposes in the educational environment.

One of the characteristic of LO is reusability which means that the LO can be used for other context and this will lead into saving cost and time instead of repeatedly authoring it. Reusability requires the LO to be in a fine-grain form because raw media elements are often much easier to reuse then aggregate assemblies. In other words, as the LOs size decreases (lower granularity), its potential for reuse increases [1] [2].

Reuse can be measured by using some of the metrics adapted from software engineering field or to be specific from object oriented approach as proposed by Cuadrado in his paper about reusability metrics [3]. Cuadrado explores the possibility of using existing metrics from Chidamber and Kemerer Object Oriented metrics [4], and adapting them to the domain of LO. Cervera et al [5] is also adapted these metrics in their study to measure reusability and quality of LO by means of correlations between the metrics and metadata. The metrics were as follows: Weighted Method per Class (WMC), Coupling Between Objects (CBO), Depth Inheritance Tree (DIT) and Lack of Cohesion on Methods (LCOM).

We are using 4 metrics from Software Engineering field to measure reusability of LOs in fine-grained form. Samples of 50 LOs were selected randomly from the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) repository and Science, Math, Engineering and Technology Education (SMETE) repository. Coarse-grained LO was a LO in a coarse form while fine-grained LO was a LO in a granular form extracted from coarse-grained LO, e.g an image, text paragraph, animation and flash video file as depicted in Fig. 1.

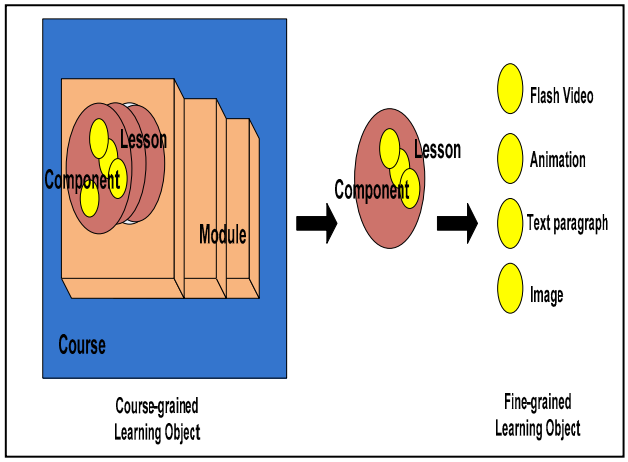

Figure 1. Coarse-grained LO to Fine-grained LO

II. ADAPTED SOFTWARE ENGINEERING FIELD METRIC

Reuse metrics for LO have been adapted from Object Oriented Software Engineering Techniques as suggested by Chidamber and Kemerer [4] and Cuadrado and Sicilia [3]. Based on Washizake et al [6] there are many software metrics are intended to measure actual reuse, only a few address reusability directly. There are four reuse metrics that we are using for this study which are Weighted Method per Class (WMC), Depth Inheritance Tree (DIT), Coupling Between Object (CBO) and Lack Cohesion of Methods (LCOM).

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A. Weighted Method per Class (WMC)

The WMC metric is the aggregation of the complexities of the methods of a given class, which could be used as a predictor for the reusability of the class from the viewpoint that classes with large numbers of methods are likely to be more application specific which limiting the possibility of reuse [6]. The concepts of method can be assimilated to the concept of interactive activity inside a composite learning object [3]. In our study, the activities are such as text paragraph, a file of flash video, animation and image. These fine-grained components are used as an activity in each learning object.

Complexities is based on one of the IEEE LOM metadata which is the aggregation level of the LO [5], based on the granularity of the LO and measured on a scale from 1 to 4, 1 is the smallest level of aggregation and 4 is the largest level of granularity. Complexity can be stated in terms of 'granularity' of activities and aggregation level in IEEE LOM metadata which is a suitable value to adapt in WMC metric.

WMC was counted based on the number of methods (activities) and complexities of methods in LOs. If WMC is high due to the high number of activities and complexities of the method, the reusability will become low.

$$WMC = \sum_{i=1}^{n} Ci$$

Where:

- n is the number of methods defined inside the class
- *Ci* is the complexity of the method i. (aggregation level)

B. Depth Inheritance Tree (DIT)

The DIT metric is defined as the count of the depth in the inheritance tree of a class inside a software framework. This metric is related to reusability as 'classes that are deeper in the inheritance tree are more complex, and thus less predisposed to reuse' [3]. The depth of the links of LO is adapted for using this DIT metric in LO [5].

The depth of the links is referred to the links between LOs in a different page. The total links in the LO are counted ups to the maximum LO. If there is too many links in the LO, the reusability will be less due to the complexity of the LOs. The granule LO which holds the lesser link will increase the level of reusability. One the other hand, if DIT is higher, the level of reusability will be lesser.

C. Coupling Between Object (CBO)

The definition of this metric according to Chidamber and Kemerer [4], is number of classes to which a class is coupled. Cervera [5] adapted this metric by checking the coupling through the links of a LO with other LOs. In IEEE LOM we can extract this information from *relation* metadata field.

LOs with no links to other LOs were given a value of 0 for this metric [5], which indicates that reuse of LO will be easy to implement. If the LO have a lot of links, reuse is difficult because the CBO is high.

D. Lack Cohesion of Methods (LCOM)

According to Cuadrado and Sicilia [3], the LCOM metric is a measure of the (lack of) overlap in the use of attributes by the methods of the class. The LCOM metric is used to check the objectives of a LO whether it is concrete enough, or is there a possibility to split the LO into several, more concrete LOs [3]. According to Cervera [3], the metric is measured by the number of different objectives that could be extracted into smaller LOs.

Usually, LO consists of one or more learning objectives. If the LO is in the form of granule, the LO learning objective is smaller and the measure of LCOM will become lesser. Therefore, for a small measure of LCOM the reusability is easily to implement in comparison to a high measure of LCOM due to a more specific learning objective.

III. ANALYSIS & RESULT

Previous study by Cervera et al [5] used 25 LOs from MERLOT to measure reusability and quality of LO for two different subject by means of correlations between the metrics and metadata. For this study, we have used 50 LOs obtained randomly from MERLOT and SMETE repository in order to measure reusability of LOs using the above mentioned 4 metrics. The 50 LOs have been extracted into 153 text paragraph, 51 images and 1 flash video. For the purpose of measuring reuse metric, we have used fine-grained LO that has been extracted so that the reusability of it can be easily applied. By using the descriptive statistic analysis, we have identified a mean value for each metric in a fine-grained form LO. Table 1 shows a range for each metric and a mean value for each reuse metric. The range for each metric is different depends on how we measured each metric. For example, WMC is based on number of activities and complexities, DIT is based on depth of the link in LO, CBO is measured by calculating link in LO and LCOM is measured by number of learning objective in each LO.

TABLE I. RANGE AND MEAN VALUE FOR REUSE METRIC

Metric	Range	Mean Value
WMC	1-6	2.35
DIT	0-7	4.14
CBO	0-6	0.81
LCOM	1-3	1.12

The WMC metric is measured based on the number of methods (activities) and complexities of methods in LOs. The range is between 1 to 6, value 1 shows that the complexities and activities were low and 6 was the highest number in this study. The mean value for WMC metric is 2.35 and this value is quite low when comparing with its range within 50's LO.

The DIT metric is measured according to the depth of the links in LO. The range is between 0-7, 0 means there is no link and 7 means there are 7 links in different page. Table 1 shows the mean value for DIT is 4.14 and this mean value

shows that this value is average when compared in its range between 0 to 7.

The CBO metric is measured by using its link to other LO. The mean value for CBO metric is 0.81 and this value is quite low when comparing with its range between 0 and 6. The range is between 0-6, 0 means there is no link and 6 means there are 6 links in the LO.

The LCOM metric is measured by the number of learning objective. In our data, normally the number of learning objective for each LO is between 1 and 3. The mean value for this metric is 1.12 so basically the average value for learning objective is 1.12.

IV. Conclusion and Future Work

The mean value for each metric is depending on how we calculate the reuse metric. Although the mean value shows that the reuse level for each metric is different, the mean value for the reuse metrics does not really exceed the middle range value (refer to Table 1). This indicates that the reusability level of all reuse metrics is generally high. This study also observes that the reuse level of WMC and CBO metrics is the highest based on the mean value of 2.35 and 0.81 respectively, as compared to DIT and LCOM. This result shows that the WMC and CBO metrics produce a high level of reuse due to a low number of activities and complexities of the method in WMC and fewer links to other LOs in CBO.

Finally, it is recommended that this study could be improved further in the field by increasing the numbers and types of LO, such as animation and video. Furthermore, it should be applied with a variety of statistical and empirical tests to prove that the software engineering reuse metric can be applied to LOs.

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